Old Colerain Pennsylvania Through Truss Bridge
Spanning Great Miami River at County Route 463
Ross Vicinity
Hamilton County
Ohio

HAER No. OH-54

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PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

Historic American Engineering Record
National Park Service
U. S. Department of the Interior
P. O. Box 37127
Washington, D. C. 20013-7127

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HISTORIC AMERICAN ENGINEERING RECORD

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Location:	County Route 463 over the Great Miami River, 1 mile south of Ross, Crosby Township, border of Butler and Hamilton Counties, Ohio UTM Coordinates: 16/703240/4352880
Date of Construction:	1894
Present Owner:	County of Hamilton (Board of Commissioners) County Courthouse Main Street Cincinnati, Ohio
Present Use:	Vehicular traffic
Significance:	The Old Colerain Pennsylvania Through Truss Bridge was built in 1894 by the King Bridge Company of Cleveland, Ohio, one of the largest and most important bridge concerns in the United States in the late 19th century. Although the company made its reputation by building bowstring bridges, this is a good example of the type of long span bridge that the company became known for towards the end of the century. The Pennsylvania truss was specifically developed for long span bridges. The bridge is listed as a "selected bridge" in the Ohio Department of Transportation's _Ohio Historic Bridge Inventory Evaluation and Preservation Plan_.
Report prepared by:	Frances A. Jones Project Historian Ohio Historic Bridge Recording Project Summer 1986.

This bridge was built in 1894 by the King Bridge Company. It is a Pennsylvania Through Truss, which is the same as a Parker truss (a polygonal top chord, and vertical posts in compression) but with additional sub-struts. The upper chord consists of channels and plate, while the struts, braces and vertical posts are of channels and lattice work. The sway bracing running between the top chords is also of channels and lattice work. Top lateral bracing is provided by bars. There are lattice work panels above the portals, and curved braces from the upper chord to these panels. Each end post is surmounted by an ornate wrought iron finial. The bridge is 368 feet long, which is quite long for a single span. It has a clear span of 360 feet and a road width of 23 feet, 5 inches. The bridge is set on stone abutments.[1]

On 3 May 1895, the Venice Graphic reported the dedication of this bridge referred to as the new iron truss bridge over the Great Miami River at Ross. It said that "There is probably no more perfect highway bridge in the United States". A large ceremony was held, but unfortunately neither the Mayor of Cincinnati, nor the County Commissioners, were able to attend due to prior engagements. H. L. Morey was called upon to speak in place of the Mayor. He said:

> "We have only to look at this beautiful structure and the massive foundations upon which it rests, and then to look at the remnants

> of the old piers of the old bridge to see that their children do things and better now than their fathers did before them. Progress and improvement have left their mark on the nineteenth century, it is stamped everywhere."[2]

It was reported that the bridge had cost $55,000 to build. It was the fourth to span the Great Miami River at that point. The first two structures were wooden and had been washed away by floods. The chance of this happening again would presumably have dissuaded the King Bridge Company from building a bridge which had to have piers to support it in the river. The third bridge was also wooden and had been destroyed by fire "of an incendiary origin".

The King Bridge Company built mainly bowstring bridges at first, but by the 1890s it was producing metal trusses of various standard types. Zenas King, the founder, had patented his bowstring design, and also a design for a swing bridge, but the company did not seem to hold patents of its own for metal truss bridges. Zenas King died in 1892, but towards the end of his life he had become interested in long spans. When spans began to approach or exceed 400 feet, bridge trusses had to be developed to cope with the specific problems of building a long span bridge. The truss had to be braced properly. It also had to be possible to fabricate it from easily available materials and sizes of members, as otherwise it would be very expensive to build.

Initially standard designs were used, and the popular Whipple truss, patented in 1849, was predominent. This had parallel chords, and inclined end posts. The verticals were in compression, and the diagonals, which were in tension, ran across two panels. It has beensaid that the history of long span bridges could be understood to have begun when it was necessary to build or replace the original Ohio River bridges with massive enough structures to take the traffic loads that were expected for the rest of the century. Most early railroad bridges over the Ohio were built in iron, as the use of iron in bridge construction was becoming common during that time period. The first long span bridge over the Ohio River was built at Steubenville, Ohio by the Pittsburgh, Cincinnati, Chicago and St. Louis Railroad. The designer was the railroad's chief engineer, Jacob H. Linville, and the bridge was built in 1863-4. There were seven spans, composed of Whipple-Murphy combination trusses. The channel span was an unprecedented 320 feet, but despite this the trusses were fairly standard in design.

Besides the Whipple truss, several other designs were used. The Warren truss (in which diagonals take both tensile and compressive forces) was fairly common in 1865, S. S. Post invented his bridge design which was quite popular for a while. This was rather like the Whipple truss, except that the vertical posts were inclined towards the center of the span. Post's design was thought to have improved rigidity under live loads, but actually the distribution of stresses was ambiguous and difficult to predict. It was acceptable in the 1860s and 70s not to be able to calculate stresses accurately on a given design. By the 1880s, however, with the increasing sophistication of the engineering profession, it was important to be able to analyze the stresses and justify a new design in theory before it was actually built.

In 1868-70 Albert Fink designed a bridge for a subsidiary of the Pennsylvania Railroad over the Ohio River at Louisville, Kentucky. His design was based in part on the principles of the Pratt and Whipple trusses. In Fink's design, however, the panels were divided into smaller units by half diagonals, and moreover the location, cross-sectional profile, dimensions and numbers of individual members were all carefully calculated on the basis of the stresses they would be carrying. Fink's design is important for this reason. Although it was complex, it was possible to predict the stresses in each of the members of his design, and these calculations were within the capabilities of any professional engineer.

The Pennsylvania Railroad engineers saw the merits of the design at once, but the calculations were complicated, and the bridge was costly to build because of the numbers of individual members, and the points of multiple intersection. They sought to simplify it by reducing the number of intermediate members within any one panel, and in 1871 they developed the "Baltimore" or "Petit" truss. This had panels divided into fewer, simpler units by a half diagonal and a half vertical member. By 1875 that was modified into the Pennsylvania truss (also known as the Petit) of which the Old Colerain Bridge across the Great Miami River is an example. The Pennsylvania truss has the same web system (pattern of members) as a Baltimore truss, but it also has a polygonal top chord in place of the older form with parallel chords. Almost all basic bridge trusses designed between 1840 and 1870 had parallel chords, but that design feature did not reflect the increase in bending moment from the ends to the center of the span. If a truss which was the same depth throughout was rigid enough at the center then it had an increasingly redundant amount of material towards the ends. The change in bending moment was recognized early on, and was reflected by the addition of a second set of diagonals in the center panels of the Pratt and Whipple trusses. The introduction of the polygonal top chord, however, was a logical step forward and became a standard feature of long span bridges. The one disadvantage was that it was more expensive to produce because of the number of different sizes of the individual members.

A variation on the Pennsylvania truss established a new record for the length of a simple span in the 1880s. It was a bridge for the Chesapeake and Ohio Railway across the Ohio River at Cincinnati, and it was designed by the Phoenix Bridge Company. The river was crossed by three spans, two of 476 feet, and the central one, across the channel, of 545 feet.[3]

THE KING BRIDGE COMPANY

The King Bridge Company, originally known as the King Iron Bridge and Manufacturing Company, was set up by Zenas King. King was not a professionally trained engineer. Like many who practiced engineering in America in the early 19th century, he learned his profession while on the job. He was born in Vermont in 1818, and grew up on a farm. In 1840 he went to Milan, Erie County, Ohio which was a booming community at that time, due to the completion of the Milan canal completed in 1839. Evidently King had some training in carpentry because there he was given contracts to build a variety of structures. King went on to spend some time working as a traveling agent for a Cincinnati cornmill manufacturer. He did not have any direct involvement with bridge building until 1858, when he became an agent for Thomas Moseley of the Moseley Bridge Company in Cincinnati. Moseley was known for having invented the first practical tubular arch bridge in America made from wrought iron boiler plates for which he recieved a patent in 1857. The company also produced the bowstring bridge which was popular from about 1850 to 1875, its attraction being that it had a high carrying capacity, relative to the amount of iron used.

King represented Moseley's company at many bridge lettings throughout southern Ohio, and thereby learned a lot about bridge design. When Moseley moved to Boston in 1860, King went to Cleveland where he set up his own bridge and boiler works. He had already begun working on his own design for a tubular bowstring bridge, and it was on this that he established his bridge building business. King, together with Peter Frees (a metal worker), produced a prototype of his design in 1859. Their bridge was not the first to use the tubular compression member for the bowstring, but it was new in that it could be easily mass produced using wrought iron boiler plate. Their design used a rectangular tube with curved parallel strips of wrought iron boiler plate riveted to channel bars at the top and bottom. On long spans, a third channel bar was riveted to the middle of the tube for extra stiffness and strength. The bridge was not patented until October 1861, as the patent office said that their design had been preceded by the English patent for a tubular bowstring bridge of 1848 by Charles DeBergue. Part of the patented design was a variation in the size of the tube, it being smallest at the abutments where it was well supported, and largest at the crown of the arch. This was actually faulty engineering, and it may never have been built with this variation in tube size since none of the existing examples demonstrate it. King carried on refining his design without Frees in the 1860s, and in 1866 he patented an improvement on it. His designs were very successful, and because the bowstrings were so light, they were cheaper to build than another design in iron or wood.

So many of King's patent bowstrings were built in Ohio that he set a design standard, with which other firms tried to compete. This helped the popularity of the bowstring bridge in Ohio in the 1860s and 1870s. During this period King built mainly bowstring bridges, examples of which fill the company's catalogues. He also built his patented tubular swing bridge, although not in such great numbers. One of the major bridges built by the company during this period however, was of a different type altogether. It was a six span Pratt deck truss built over the Mississippi at Minneapolis in 1874. It was 1110 feet long, and took only four months to build.

As time passed the designs produced by the company did vary, and they gradually built fewer bowstrings. They received many contracts for double intersection Pratt through trusses, and by the 1880s were building as many of those as they had built bowstring bridges in the 1860s and 70s. This was following a national trend, as the bowstring bridge was virtually abandoned after 1880. Professional engineers had never been fond of the design. It was difficult to brace properly overhead, and so it had a strong tendency to sway sideways. King hired more and more professional engineers from the late 1870s, and it may be because of their influence that the bowstring was gradually abandoned by the company.[4]

King joined up with six other Cleveland businessmen to incorporate the King Iron Bridge and Manufacturing Company (KIBMC) in 1871. The other men involved were Thomas A. Reeve, A. B. Stone, Charles E. Barnard, Charles A. Crumb, Dan P. Eells and Henry Chisholm.[5] The incorporation provided the company with more money and links with the Cleveland iron, legal and financial community. He was not the only Ohio bridge builder to incorporate, but he did so earlier on in the company's life than was typical. One of the biggest differences between this company and other large bridge companies of the period was the emphasis on advertising and sales techniques. By the late 1860s the company had agents or salesmen throughout the nation who could represent the company at bridge lettings. Other companies also did this, but not on the same scale. KIBMC also produced impressive catalogues at regular intervals, and it had so many contracts west of the Mississippi that several subsideries of the King Bridge Companies were established there.

Even if the Company was not responsible for a bridge design, it developed innovative methods of construction to overcome a specific problem. They did this with the Central Viaduct in Cleveland, where they produced a method of building the spans without using falsework.[6] Although the company began by concentrating on the bowstring, by the late nineteenth century it was building deck trusses, low trusses, various single and multiple intersection through trusses, combination bridges and girder and swing bridges. Many bridge companies also produced a variety of iron and steel work for buildings and roofs. KIBMC produced parts for "furnace plants, mills, or any style of fire-proof construction desired; also hoisting and conveying machinery for handling ore, coal etc."[7]

By the late nineteenth century the Company had an impressive and up to date plant. Engineering News wrote about it in 1891 in its "Notes on a trip to Chicago and Cleveland":

> The works are well arranged for the progress of work: material is delivered from the cars under cover, and proceeds through the shops to the painting and finishing shop, where it is loaded on to cars on a depressed track. The erection of turntables for drawbridges is done on a floor having a concrete foundation, and there is an overhead circular traveling trolley for the handling of the materials. The blue print room attached to the drawing office is quite large, and has large windows with yellow glass, so that the work can be carried on without inconvenience.[8]

The plant was located on both the Pennsylvania, and Lake Shore and Michigan Southern Railroads. By 1893 it had an area of 155,000 square feet under cover, and the latest machinery had been installed. In about 1893 they added a plant for the manufacture of steel eye-bars "by the latest and improved methods". They were said by one commentator to be "one of the few manufacturing companies to make this class of material".[9]

Attention had begun to be focused on plant design in the 1860s and 70s. An American engineer, Alexander Lyman Holley, designed a number of innovative plants for the steel industry at this time, and he said that his main aim was "to assure a very large and regular output". Plants were designed to make the fullest possible use of existing transportation facilities with buildings laid out to follow the curves of railroad tracks. The site was laid out in order of the processes of production. One of the works Holley designed was so successful that it became the most efficient steel producer in the United States, or in the world (for more information on Holley and plant design please see the section on the Wrought Iron Bridge Company in the report on the White Bowstring Pony Truss Bridge, HAER No. OH-39).[10]

King died in 1892, but unlike many family owned corporations, the company carried on, and was still operating through the second World War. After King's death the name of the company was officially shortened to "King Bridge Company" for the sake of convenience. The administration was taken over by Zenas King's son, Harry Wheelock King. The company began to have some problems, and he was forced to reduce the value and amount of the capital stock in 1906. It was in that year that the company was the defendant in a civil action resulting in its official dissolution.

Many bridge companies in Ohio had been involved in bridge pools (cartels), a system of agreements between participating companies which enabled them to keep prices at a certain (sometimes very high) level.

It meant that there was no true competition for bids, as in many cases the companies had already decided which of the supposedly secret bids submitted by them would be the lowest. These agreements had been in operation for some years, but companies were not taken to court in Ohio until the early 1900s. Some of the biggest cartels had been organized by railroad companies, which had had informal agreements at first. After the onset of the 1873 Depression, however, these agreements were formalized in an attempt at mutual protection from bankruptcy. By the 1880s the railroad cartels were clearly breaking down, and they were also forbidden by the Interstate Commerce Act of 1887.[11] Bridge cartels were not attacked until much later, but when they were many companies were found to be deeply involved, with the King Bridge Company being one of the worst offenders (presumably because it was one of the largest organizations of its kind). The laws in New Jersey were not as stringent, and it is presumably because of the 1906 court case that the company technically moved, and became the King Bridge Company of New Jersey. The company was reorganized again in the 1920s under Norman C. King, who had been secretary of the preceding corporation. The firm finally disappeared from the Cleveland City Directories shortly after the Second World War.[12] (For more information on bridge pools please see the report on the Forder Pratt Through Truss Bridge, Paulding County, Ohio HAER No. OH-42).

NOTES

1 The bridge does not seem to appear in the County Commissioners Journals for the period, which is odd for a bridge of this size. It may be that it is the bridge mentioned as being in or near Venice, for which there are entries for c. 1894.

2 Venice Craphic, 3 May 1895, quoted in The Cincinnati Enquirer, Friday 6 May 1983, C-4 Metro.

3 All information on long spans is from Carl W. Condit, American Building Art: The 19th Century (New York: Oxford University Press, 1960) pp. 141-9.

4 David A. Simmons, "Zenas King: A Bridge Builder of National Proportions" (unpublished article held at the Ohio Historical Society).

5 William Gason Rose, The Making of a City (Cleveland and New York: World Publishing Company, 1950) p. 287.

6 David A. Simmons, "Zenas King".

7 Civil Engineers Club of Cleveland, Visitor's Directory to the Engineering Works and Industries of Cleveland, Ohio (1893) pp. 55-7.

8 "Notes on a Trip to Chicago and Cleveland", Engineering News (26 December 1891): 609.

9 Civil Engineers Club of Cleveland, Visitor's Directory.

10 Alfred D. Chandler Jr. The Visible Hand: The Managerial Revolution in American Business (Cambridge, Massachusetts: The Belknap Press of Harvard University Press, 1977) pp. 259-66.

11 Alfred D. Chandler Jr. The Visible Hand, pp. 124-44.

12 David A. Simmons, "Zenas King".

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Bridge Files, Ohio Historical Society (compiled by David A. Simmons, OHS).